Rod Derotation Techniques for Thoracolumbar Spinal Deformity

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OBJECTIVE: The operative correction of scoliosis requires multiple intraoperative techniques and tools to achieve an adequate result. Frequently, multiple methods are used to accomplish this, such as rod cantilever techniques, in situ bending, Smith-Petersen and pedicle subtraction osteotomies, closed reduction methods, and rod derotation techniques. Rod derotation techniques will be reviewed and discussed in this article.

METHODS: A review of the available literature on anterior and posterior rod derotation is performed with a case example of the authors' experience utilizing this technique.

RESULTS: Rod derotation is one technique that can transform a pathological scoliotic curve to normal physiological kyphosis or lordosis by simply rotating a rod intraoperatively.

CONCLUSION: In this article, the authors present rod derotation as a valuable technique in the surgical arsenal for the treatment of scoliosis, including a discussion of the technique and its limitations.

KEY WORDS: Deformity reduction, Rod derotation, Scoliosis, Spinal deformity

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Spine deformity is an altered alignment that exceeds normal limits for a particular spinal region and can be evaluated in three planes: sagittal (kyphosis/lordosis), coronal (scoliosis), and axial (degrees of rotation). Patients with adult spinal deformity will infrequently have a simple curvature in just one plane. More often, adult idiopathic and degenerative scoliosis is a three-dimensional spinal deformity. Typically, the spine is laterally deviated in the coronal plane in association with a relative hypokyphosis (thoracic) or hyperkyphosis (lumbar) in the sagittal plane in addition to being rotated in the axial plane. A variety of surgical techniques have evolved over the years to help correct such complex spinal deformities.

With this three-dimensional deformity in mind, Cotrel et al. (6a) pioneered the technique of attaching a concave rod to the posterior spinal elements followed by rod rotation to reduce the deformity. This rod rotation corrects the scoliosis by bringing the spine to midline in the coronal plane and establishing thoracic kyphosis or lumbar lordosis (posterior medialization effect). This technique can be performed anteriorly, although it is performed most commonly via a posterior approach with instrumentation and fusion. Surgical treatments have evolved to maximize the amount of correction and minimize fusion levels, and spinal instrumentation has followed suit with the evolution from Harrington distraction rods to wire, hooks, and pedicle screws. These advances in spinal fixation techniques have become more effective in applying the forces needed to correct the scoliotic spinal deformity.

ABBREVIATIONS: HZI, Halm-Zielke instrumentation; **ICU**, intensive care unit; **VATS**, Video Assisted Thoracocopic Surgery; **VDS**, Ventral Derotation Spondylodesis

History of Derotation Techniques

In 1962, Harrington (10a) introduced a posterior sublaminar hook system that applied distraction and/or compression forces to improve scoliotic deformities. This system addressed the scoliosis in the coronal plane but was limited in its ability to control contour in the sagittal and axial planes. In the early 1980s, to address the three-dimensional aspects of scoliotic deformities, Cotrel and Dubousset introduced a new instrumentation system that allowed the use of derotation techniques. This evolved into the development of transpedicular fixation, which allowed for better pull-out strength and load-bearing capacity. Currently, there are many different spinal instrumentation systems on the market that use pedicle screws and rods that can be bent and rotated to correct scoliotic deformities.

Anterior approaches and instrumentation have been used for several decades for the correction of scoliosis. Dwyer et al. (8) and Zielke (24) contributed to the development of anterior spinal instrumentation. In 1969, Dwyer et al. (8) published a description of an anterior instrumentation system for the correction of scoliotic deformity. Disadvantages of the implant were its limited axial derotation, significant kyphotic effect, and pseudoarthrosis with screw pullout and cable fractures. To prevent this effect, ventral derotation spondylodesis was developed, also known as Zielke instrumentation. Both the Dwyer and Zielke systems allow for shorter fusion lengths, as compared with posterior double-rod systems. The major shortcoming of the Zielke system, which uses a single threaded rod, is instrumentation failure because of its limited stability. Even with postoperative bracing, the rod breakage rate is as high as 43%, with loss of correction in anterior single-threaded-rod instrumentation systems.

A prospective randomized study comparing posterior double-rod instrumentation with anterior single-threaded-rod instrumentation (3.2 mm) for the treatment of adolescent idiopathic scoliosis demonstrated that the coronal correction and spinal balance in both groups was identical (3). The anterior group needed shorter fusion. Compared with posterior fusion, the anterior approach saved 2.5 lumbar segments on average. However, an unacceptably high rate of rod breakage (31%) was noted in the anterior group, with loss of correction and pseudoarthrosis, which limited the usefulness of anterior scoliosis surgery.

These results forced the development of anterior double-rod systems such as the Kaneda and Cotrel-Dubousset-Hopf spinal instrumentation systems (11, 12). Rod breakage was essentially prevented with these systems. However, they are limited in the amount of correction that can be achieved. In addition, the increased rigidity of the rods caused screw breakout during or after surgery at the cranial and caudal ends of the construct and was a leading mechanism of failure.

Halm developed a system to combine the advantages of single-threaded-rod systems (excellent correction and derotation) with the advantages of the anterior double-rod systems (increased stability) (6, 9, 10). The Halm-Zielke instrumentation thus consists of a dual-rod system with a flexible rod and a second solid rod. In a prospective study on idiopathic scoliosis (14a), it was shown that the Halm-Zielke instrumentation provided good correction, including apical rotation, and eliminated implant failure. Only two patients had pseudoarthrosis at the 2-year follow-up.

Muschik et al. (16) compared anterior and posterior double-rod instrumentation for thoracic idiopathic scoliosis in 141 patients. The amount of correction was similar in both groups except for thoracic and lumbar rotation, which was better with anterior instrumentation. The number of fused segments was smaller for the anterior group. The rates of complications were identical. Therefore, these results confirm the role of anterior spinal surgery and instrumentation for scoliosis correction.

THORACOSCOPIC SPINAL SURGERY

Although modern anterior techniques for spinal surgery have been shown to be effective for scoliosis correction, they usually require a thoracotomy or thoracoabdominal approach for anterior access. These approaches use a large incision, extensive muscle dissection, rib removal, and large diaphragmatic incisions. This can result in increased blood loss, diaphragmatic hernias, pulmonary complications, and postoperative pain. In addition, postoperative management frequently includes a chest tube and intensive care unit stay. Chronic morbidities include chronic post-thoracotomy syndrome and poor cosmesis of the larger incisions, with muscle atrophy. To avoid the excess morbidity resulting from anterior spinal access, minimally invasive techniques were developed.

Jacobaeus, in the early 1900s, developed thoracoscopy for the treatment of lung disease, with further development of video recording techniques and cameras allowing Regan et al. (19) in the 1990s to use video-assisted thoracoscopic surgery for spinal surgery (1). Video-assisted thoracoscopic surgery has been refined for use in thoracic microdiscectomies and corpectomies, thoracolumbar fractures, tumors, and infections (1, 2, 5, 7, 20, 21). Thoracoscopic surgery for deformity correction includes anterior release, discectomy, interbody fusion, and instrumentation (15). Pollock et al. (18) compared thoracoscopic release and posterior fusion with open release and posterior fusion. They achieved similar corrections of Cobb angles using the minimally invasive technique. Experience and outcomes for thoracoscopic scoliosis surgery have increased steadily. More recent studies confirm that thoracoscopic spinal instrumentation for scoliosis compares favorably with posterior fusion. Lonner et al. (15) reported good coronal correction rates, sagittal contour, and spinal balance. The advantages of the thoracoscopic approach were the need for fewer fusion segments, reduced blood loss, fewer transfusions, and improved cosmesis. However, the operative time was nearly twice as long for the thoracoscopic group, with a steep surgeon learning curve. They concluded that additional studies are required to confirm the precise role of thoracoscopic approaches for adolescent idiopathic scoliosis.

PATIENT SELECTION

Appropriate patient selection is the key for maximizing the surgical benefits and minimizing the potential complication risks of a rod derotation maneuver. This process begins with a standard scoliosis workup, including a history (i.e., prior spinal, abdominal, and/or thoracic operations) and a physical examination. Full-length posteroanterior and lateral x-rays are used to identify the end vertebrae, neutral vertebrae, apical vertebra, and intermediate vertebra. Lateral bending x-rays with the patient in the supine and standing positions are used to evaluate the flexibility of the scoliotic curves. Further imaging, such as computed tomography or magnetic resonance imaging, may be indicated to further assess the bony and neural anatomy in patients who have undergone previous surgery, have complicated anatomy (e.g., spina bifida) or associated neurological symptoms (e.g., radiculopathy or neurogenic claudication), or have any other situation that may affect the surgery. Pulmonary function tests may also be warranted in patients with baseline pulmonary compromise.

The best indications for derotation would be a single lumbar, thoracolumbar, or thoracic curve—ideally, flexible main thoracic curves with an associated hypokyphosis, or a flexible lumbar curve with an associated hyperkyphosis. The false double major King Type 2 curve is considered contraindicated because predicting the response of the generally more flexible lumbar curve portion to the instrumention and correction of the more stable thoracic curve portion can be difficult (4). The hope is that the lumbar curve will revert to a more normal alignment without instrumentation, thus saving motion segments for the patient. Scoliotic curve flexibility of greater than 50% helps to ensure the plausibility of intraoperative derotation. An anterior release procedure may be warranted for more rigid curves.

APPROACH SELECTION

There are many factors that must be taken into account when determining whether an anterior, posterior, or combined approach is most appropriate for a specific patient. Previous surgery can quickly eliminate certain approaches, as can anatomic defects such as the absence of posterior elements in spina bifida. In addition, a patient may have a preference for a certain scar location (i.e., lateral thoracic versus posterior spinal).

Anterior vertebral rotation offers the potential benefits of decreased blood loss, kyphotic effect for a lordotic deformity, prevention of erector musculature denervation, and absence of prominent implants. The kyphotic effect of anterior surgery has been shown to be advantageous in a patient with preoperative hypokyphosis (≤20 degrees) (3). Anterior fusion can also have a smaller number of fused levels, saving motion segments (3, 16). The kyphotic effect of the anterior approach for derotation leads to this being contraindicated in a patient with kyphoscoliosis. In addition, this approach should be avoided in a patient with rotation of the lowest vertebra greater than 15 degrees or 20% of the pelvic axis. Potential complications of an anterior approach include sympathectomy, deep venous thrombosis, postoperative ileus, great vessel damage, occasional difficult access to certain levels (i.e., L1, L2), and diaphragm disruption. In addition, thoracic wall denervation could have a serious effect in a patient with a preoperative depressed pulmonary function.

A posterior approach allows for preservation of thoracic wall musculature and decompression of neuroforamina and the central canal, and it prevents the need for an approach surgeon. A posterior approach is also more ideal for patients who require fusions of multiple curves (4). The lordotic effect of posterior fusions has been shown to be advantageous in a patient with preoperative hyperkyphosis (≥40 degrees) (3). Disadvantages include erector musculature denervation, larger blood loss potential, and risk of neural and/or dural injury.

Controversy exists regarding the possible benefit of a combined approach (i.e., whether or not an anterior release enhances posterior derotation). For idiopathic adolescent scoliosis, it is generally felt that a combined approach is not of added benefit (4, 22). However, one situation in which a combined approach is usually thought to be beneficial is in adult degenerative lumbar scoliosis (4). Very rigid curves, severe thoracic kyphosis (≥70 degrees), and/or frank lumbar kyphosis may also benefit from a combined approach.

SURGICAL TECHNIQUE

Posterior Vertebral Rotation

(see video at web site)

The surgical technique for derotation of scoliosis from a posterior approach is actually very simple in theory (*Fig. 1*), but execution is dependent on a number of variables. Preoperative planning is essential, with standing scoliosis x-rays of the entire spine along with lateral bending x-rays used to determine the amount of correction needed, flexibility of the curvature, and strategic vertebrae (apical, neutral, and intermediate

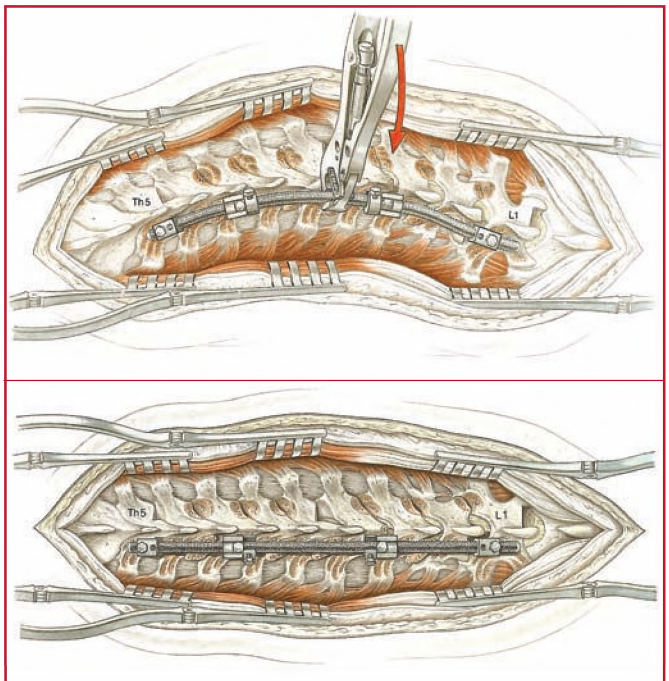

FIGURE 1. *Illustrations of the posterior rod derotation technique using the Cotrel-Dubousset system (from, Bauer R, Kerschbaumer F, Porsel S:* Atlas of Spinal Operations. *New York, Thieme, 1993, pp 140).*

TABLE 1. Examples of instrumentation systems for performing derotation

Anterior systems
Medtronic CD Horizon Antares® Spinal System[a]
DePuy Frontier® Anterior Deformity System[b]
DePuy Anterior Isola Spine System[b]
Stryker XIA® Anterior Spine System[c]
Posterior systems
Medtronic CD Horizon® Legacy™ Spinal System[a]
Medtronic TSRH-3D® Spinal Instrumentation[a]
DePuy Isola/VSP Spine System[b]
DePuy Expedium™ 6.35 Spine System[b]
Zimmer ST360°™ Spinal Fixation System[d]
Synthes Click'X Spine System[e]
Synthes Pangea System[e]
Synthes Universal Spine System[e]
Stryker XIA® Spinal System[c]

[a] Medtronic Sofamor Danek, Memphis, TN.
[b] DePuy Spine, Raynham, MA.
[c] Stryker Spine, Allendale, NJ.
[d] Zimmer, Inc., Warsaw, IN.
[e] Synthes, West Chester, PA.

vertebrae) that need to be incorporated into the fusion construct. These landmarks will also determine the location of critical pedicle screw fixation points for force application to reduce the deformity along with the construct needed to stabilize the spine. There are a number of manufacturers of posterior pedicle screw-and-hook systems that can be used (*Table 1*). The system chosen does need to include monaxial screws or rigid pedicle screwdrivers to manipulate the deformity, as polyaxial-head pedicle screws ease completion of the long construct but do not facilitate any significant manipulation. Stainless steel or cobalt chrome rods will provide a more ductile metal to manipulate and bend versus the more brittle titanium; however, they will cause more artifacts and problems with postoperative imaging. One important point is that the metal will always be stronger than the bone, and the screw or hook will cut through the bone if one attempts to "power through" the reduction. This occurs more frequently in osteoporotic patients or if the spine is not flexible, with incomplete osteotomies or release, and can be avoided if friction-glide tightness is applied to the screw or hook interface to the rod to allow for some play during the reduction.

Once under general anesthesia and paralytics, the patient is placed prone on a radiolucent table, which facilitates intraoperative imaging. With a flexible deformity, closed traction is used to achieve as much reduction as possible before placing the final pressure pads and safety straps on the patient. This can be performed manually with a two-person reduction maneuver (*Fig. 2*). One person stands at the head and holds onto a sheet wrapped under the chest and axilla to provide traction superiorly, whereas the other person applies inferior traction by grasping onto the iliac crest. With closed reduction using traction, the circulating nurse can apply additional pads and bumps under the contact areas on the patient that may have risen up to stabilize and hold the reduction. With only open reduction using pedicle screws, there can be gravity effects on reducing and derotating the patient that alter the contact areas between the patient and the operative table. This alters the load bearing by the operative table, which can increase the difficulty in holding the derotation and reduction of the spine with the spinal implants.

FIGURE 2. *Photograph demonstrating the intraoperative closed reduction technique.*

The spine is then exposed in a fashion similar to other posterior instrumented fusions. We recommend making a linear skin incision for cosmesis rather than a curvilinear one based on the spinal deformity. Subperiosteal dissection is then completed to expose the costotransverse junction in the thoracic and transverse processes in the lumbar region. The facet joints of the spinal segments at the curvature on the concave side are disrupted to allow better deformity reduction with distraction. Posterior osteotomies, pedicle subtraction osteotomies, and Smith-Petersen osteotomies can be used as needed to mobilize and allow for deformity correction with compression of the convex side or posteriorly for reduction of a kyphosis. Otherwise, laminectomies and facetectomies are performed as needed for decompression of the neural elements based on preoperative scans.

Pedicle screws (monaxial on the side that will be used for derotation) are placed across the deformity. Preoperative planning is needed to choose the largest diameter and best length screw for each level to maximize pedicle and vertebral body purchase. Special attention is given to placing pedicle screws at the rostral and caudal ends of the curve, with at least one screw at the center of the curve (apex). These points in the

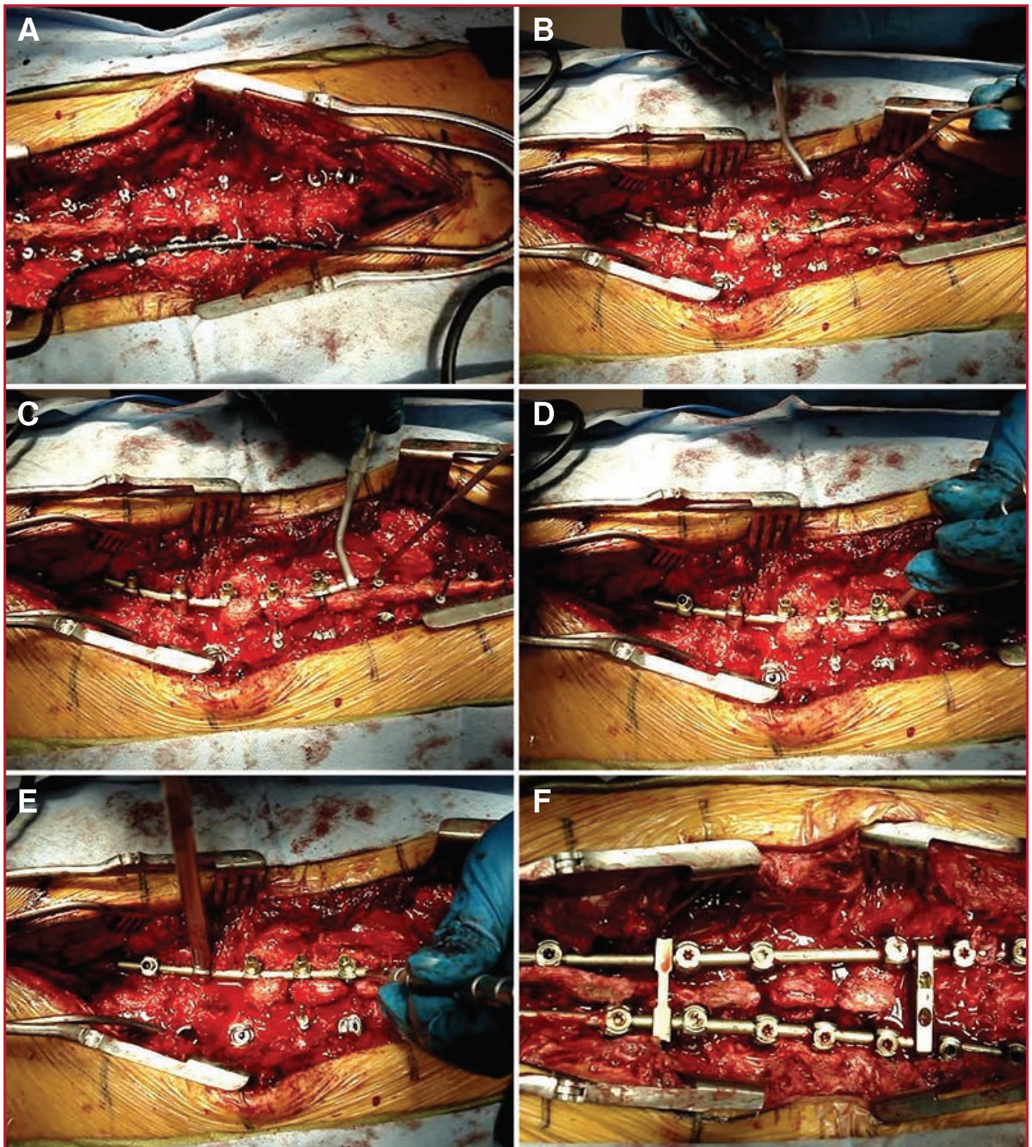

FIGURE 3. *Intraoperative photographs of the posterior rod derotation technique.* **A**, *malleable rod templating.* **B**, *pre-bent rod is loosely attached.* **C–E**, *derotation maneuver.* **F**, *final result after compression, distraction, and final tightening.*

curve are necessary for any derotation procedure to work, and it is important to place as many as are as needed along the curve to allow for maximum construct strength. However, this will be dependent on the individual patient and the curvature reduced.

A malleable template is used to determine the contour of the rod needed to fit in the current scoliotic curve and the final kyphosis or lordosis. This rod is then placed across this abnormal curve, secured with set screws loosely, and then rotated into the sagittal plane, transforming the coronal deformity into kyphosis or lordosis in the sagittal plane (*Fig. 3*). A rod is then placed on the opposite side to lock in the corrected position. Because this maneuver may not provide physiological lordosis/kyphosis, use of techniques such as in situ bending irons, direct derotation using the pedicle screwdrivers, and compression and distraction can then be applied to approximate sagittal balance and correct residual coronal deformity. Once the contralateral side is secured to hold the reduction, the derotation rod is then replaced with the final rod, and cross-links are used to strengthen the construct. After the deformity is reduced using derotation techniques, a normal posterolateral fusion completes the procedure. In addition to rod derotation, other helpful techniques include distraction of concave segments, compression on convex segments, compression of wide intervertebral spaces, distraction of narrow intervertebral spaces, distraction of hyperlordosis, and compression of hyperkyphosis.

There are many complications and pitfalls associated with rod derotation and other techniques used in the correction of deformity. These include pedicle fracture, nerve root injury, instrumentation construct failure, adjacent level degeneration, and, obviously, infection. With respect to rod derotation, it is important to avoid pedicle fracture and nerve root injury. To avoid pedicle fracture, it is important to complete adequate release and osteotomy techniques before derotation to avoid placing too much stress on the pedicle screws during derotation. In contrast, if proper release techniques have been used and the rotation facilitates significant movement, nerve roots can be damaged as the foramina narrow and change in configuration throughout the derotation.

Anterior Vertebral Rotation

The surgical technique for derotation of scoliosis from an anterior approach is very similar in concept to that from a posterior approach. Again, the importance of preoperative planning cannot be overstated.

General anesthesia is administered with double-lumen intubation, and the patient is placed in the lateral decubitus position with the concave side of the scoliotic curve down. A transthoracic approach can be performed to expose down to the 12th thoracic vertebral body and even the 1st lumbar vertebral body. However, a transpleural retroperitoneal approach is needed to instrument more caudal lumbar levels. After the desired vertebral bodies are exposed, standard anterior discectomy, endplate removal, and interbody fusion are performed. Combinations of cortical and cancellous allograft and autologous rib can be used for the fusion, which may require that the patient undergo rib resection and thoracoplasty of several ribs. The desired final sagittal alignment determines the amount and type of graft used. For instance, in a patient with preoperative kyphosis, a weight-bearing bone graft or cage may be needed.

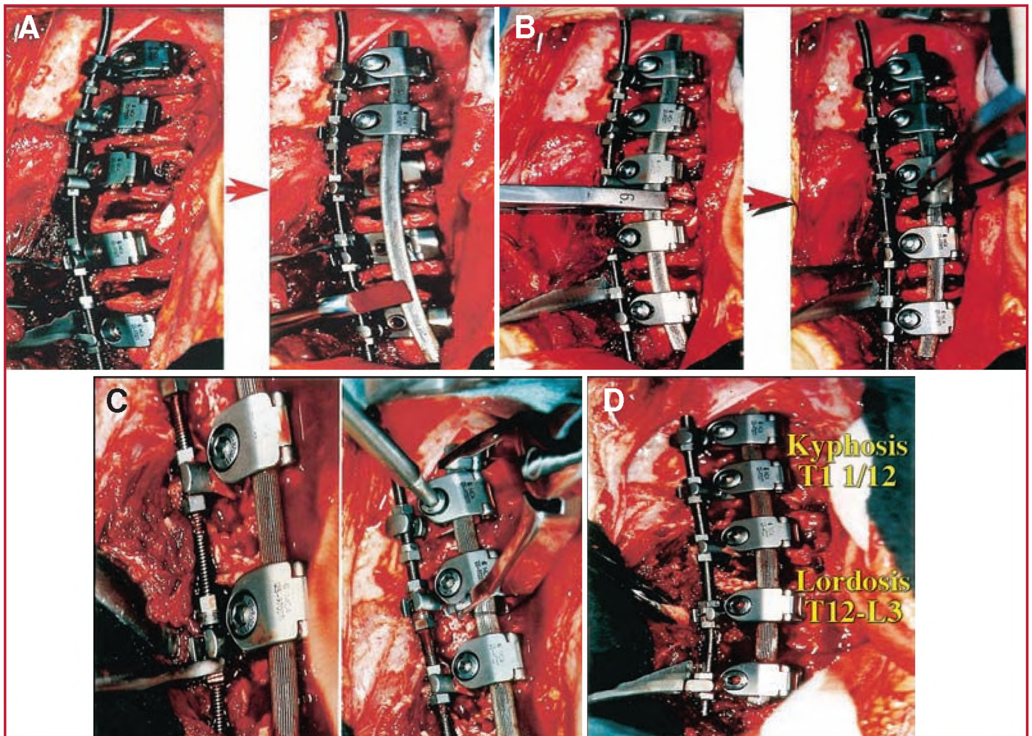

FIGURE 4. *Intraoperative photographs of the posterior rod derotation technique.* **A**, *after attachment of the lid plates to the vertebral bodies, initial correction is obtained with insitu bending of the threaded rod, followed by insertion of the solid rod.* **B**, *derotation maneuver with force centered over apex of curve.* **C**, *further compression.* **D**, *the final desired alignment* (from, *Halm HF, Liljenqvist U, Niemeyer T, Chan DP, Zielke K, Winkelmann W: Halm-Zielke instrumentation for primary stable anterior scoliosis surgery: Operative technique and 2-year results in ten consecutive adolescent idiopathic scoliosis patients within a prospective clinical trial.* ***Eur Spine J*** *7:429–434, 1998 [10]*).

A Halm-Zielke instrumentation lid plate is then attached to the lateral aspect of each vertebral body with two screws, an anterior sunk screw and a posterior ventral derotation spondylodesis screw (*Fig. 4*). A 4-mm threaded rod is placed in the heads of the ventral derotation spondylodesis screws and loosely held in place with collared hexagonal nuts. An initial partial correction is obtained with in situ bending of the threaded rod. A pre-bent, solid, fluted, 6-mm rod is then placed in the lid plates, and the lids are loosely tightened. Then, the fluted rod is rotated, with the force centered on the apical vertebra to obtain the desired derotation effect. Care must be taken to apply enough force for derotation but not so much that it would fracture a vertebral body and cause screw breakout. This requires monitoring the instrumentation and bone interface during the maneuver to watch for early bony failure and hardware dislodgement. Once the fluted rod is rotated, the construct is fine tuned with intersegmental compression on the convex side and distraction on the concave side to achieve the final correction, and all of the pieces are given final tightening (*Fig. 5*).

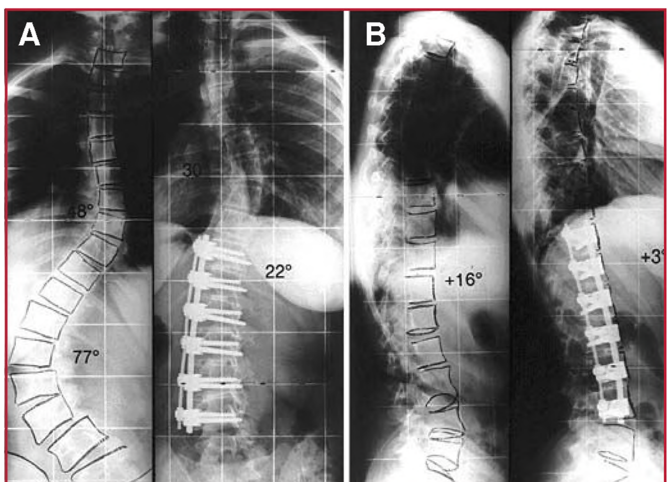

FIGURE 5. *Preoperative* (**A**) *and postoperative* (**B**) *scoliosis x-rays showing anterior correction and instrumentation* (from, *Halm HF, Liljenqvist U, Niemeyer T, Chan DP, Zielke K, Winkelmann W: Halm-Zielke instrumentation for primary stable anterior scoliosis surgery: Operative technique and 2-year results in ten consecutive adolescent idiopathic scoliosis patients within a prospective clinical trial.* ***Eur Spine J*** *7:429–434, 1998 [10]*).

Thoracoscopic Techniques

Picetti and Pang (17) have described an anterior thoracoscopic approach for scoliosis correction. In this technique, general anesthesia is achieved with a double-lumen endotracheal tube, and the patient is placed in the lateral decubitus position with the concave side of the scoliotic curve down. Using fluoroscopy, an initial portal is placed in the midaxillary line over the 6th or 7th rib, in line with the spine. An endoscope is inserted into the portal and, under direct visualization, additional portals are placed two interspaces apart. The vertebral bodies are then exposed, and discectomies and endplate removals are performed. An endoscopic rib cutter is used to obtain an autograft from the superior aspect of each rib to be harvested. Using Kirschner wires and fluoroscopy, bicortical vertebral body screws are guided into position parallel to the endplates and in the center of each vertebral body. Once the screws are placed, the graft is inserted into each interbody space. An endoscopic rod measurer is used to determine the rod length. A 4.5-mm rod with slight flexibility is then cut and inserted unbent through the most inferior portal. The rod is first secured to the most inferior screw to prevent injury to the diaphragm. The rod is then manipulated into the screw heads sequentially, with the help of endoscopic instruments, and attached loosely. A derotation maneuver and then compression between the screws can be performed to achieve the desired correction. After final tightening of all of the screw heads, a chest tube is placed through the inferior portal, and the patient is extubated and taken to the postanesthesia care unit.

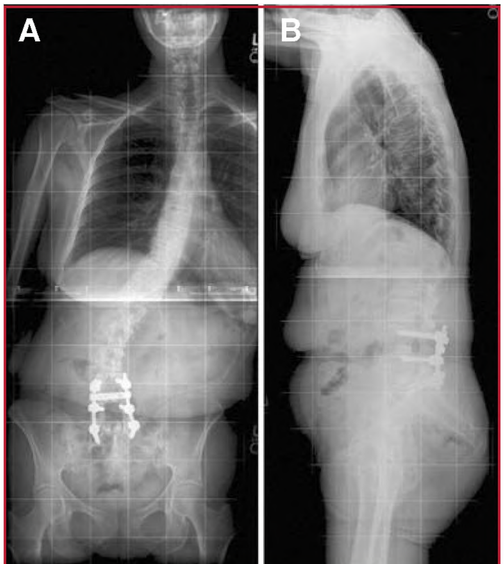

FIGURE 6. *Preoperative anteroposterior (**A**) and lateral (**B**) x-rays of a 50-year-old woman with severe dextro- and rotatory scoliosis of the lumbar spine with compensatory levoscoliosis at the thoracolumbar junction.*

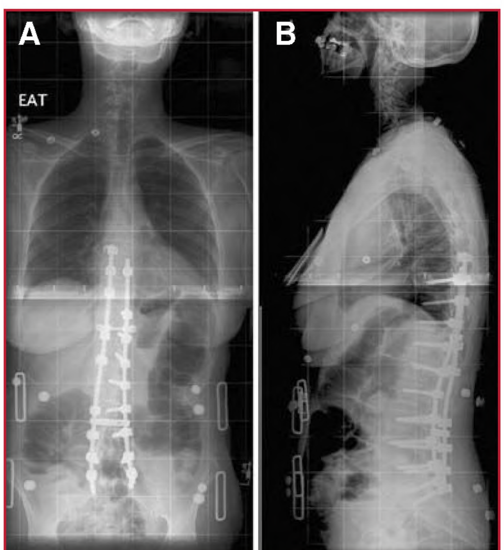

FIGURE 7. *Postoperative anteroposterior (**A**) and lateral (**B**) scoliosis x-rays obtained 3 days after surgery.*

ILLUSTRATIVE CASE

A 50-year-old woman with prior L4–S1 fusion presented with a progressive scoliotic deformity associated with significant back and radicular pain. Preoperative x-rays showed severe dextro- and rotatory scoliosis of the lumbar spine with compensatory levoscoliosis at the thoracolumbar junction with a progressive and mobile deformity (*Fig. 6*). She was taken to the operating room for removal of the prior hardware and underwent a T8–S1 posterolateral lumbar fusion with T12–L4 posterior vertebral osteotomies and release with open reduction of the thoracolumbar rotatory kyphoscoliosis using the rod derotation technique, without complication (*Fig. 3*). This case was chosen to demonstrate the amount of correction that can be achieved with rod derotation in a patient with a mobile deformity (*Fig. 7*). Rod derotation was successful for her because she had a mobile deformity that provided significant reduction with traction at surgery. After traction, there was still a significant coronal deformity from T12 to L4. This T12–L4 region was the location of the short rod used for derotation (*Fig. 8*).

DISCUSSION

Rod derotation is an elegant technique for the reduction of scoliosis. It is simple in theory and effective at rotating a scoliotic helix toward the sagittal plane (23). The amount of derotation of the individual vertebrae in the axial plane may be limited in a pure rod rotation correction, according to Lee et al. (14), but this is disputed by Tredwell et al. (23), who suggest that there is significant apical vertebral rotation in posterior derotation maneuvers in addition to the overall correction of a coronal deformity into the sagittal plane.

However, there are limitations as, often, the scoliotic curve has a Cobb angle of 50 degrees or greater that, when translated to kyphosis or lordosis, can be greater than normal physiological curvature. This hyperlordosis and/or kyphosis often requires in situ bending to achieve a physiological curvature. Also, scoliotic deformities often include both thoracic and lumbar components, requiring multiple derotations and other techniques.

There are many different instrumentation systems available, but regardless of which system is used, monaxial screws are recommended for the derotation technique (13). The polyaxial systems, though easier to use for rod placement, allow too much movement and are thus ineffective on the side of the rod derotation.

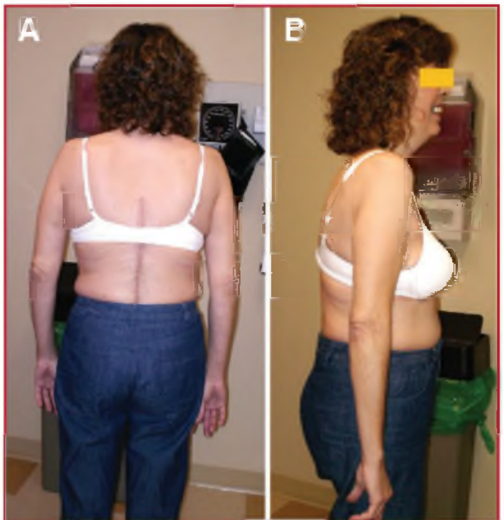

FIGURE 8. *Postoperative patient photographs. The patient noted substantial improvement in her preoperative pain at her 6-week and 3-month follow-ups. This is the same patient pictured in Figures 6 and 7.*

As described, both anterior and posterior approaches are used in the correction of scoliosis. Rod derotation is often described from the posterior approach but can also be used in open anterior and thoracoscopic approaches (15). The procedure is different, but the principle of rotation of an abnormal curve into the sagittal plane is the same.

CONCLUSION

Rod derotation is one surgical technique that provides an elegant and effective means of reducing scoliotic deformity. By itself, there are obvious limitations, but when used in concert with other techniques, it provides a powerful tool for the surgical treatment of deformity correction. As further advances continue with minimally invasive techniques and better understanding of bone biology, less disruptive surgical options may become available in the correction of spinal deformities.

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